



A Climate-Quality Data Record of the Ice-Surface Temperature of the Greenland Ice Sheet

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Much recent work has shown that the Greenland Ice Sheet has been experiencing increasingly extensive melt, resulting from well-documented Arctic warming. The objective of this work is to create a climate-data record (CDR) of the ice-surface temperature (IST) of the Greenland Ice Sheet, so that temperature trends and melt extent can be monitored on a decadal time scale. Advanced Very High Resolution (AVHRR) Polar Pathfinder (APP) data, beginning in 1981, may be used as the early part of the record, followed by Moderate-Resolution Imaging Spectroradiometer (MODIS) data starting in 2000, and Visible Infrared Imager Radiometer Suite (VIIRS) data beginning in late 2011, to create a 30+ year record of “clear-sky” surface temperature.

We have developed a climate-quality data record of the “clear-sky” surface temperature of the Greenland Ice Sheet using Terra MODIS IST data. Daily and monthly Terra MODIS ISTs are available beginning in March of 2000 and continuing through the present at 6.25-km spatial resolution on a polar stereographic grid as binary files. The complete MODIS IST dataset will soon be freely available to download.

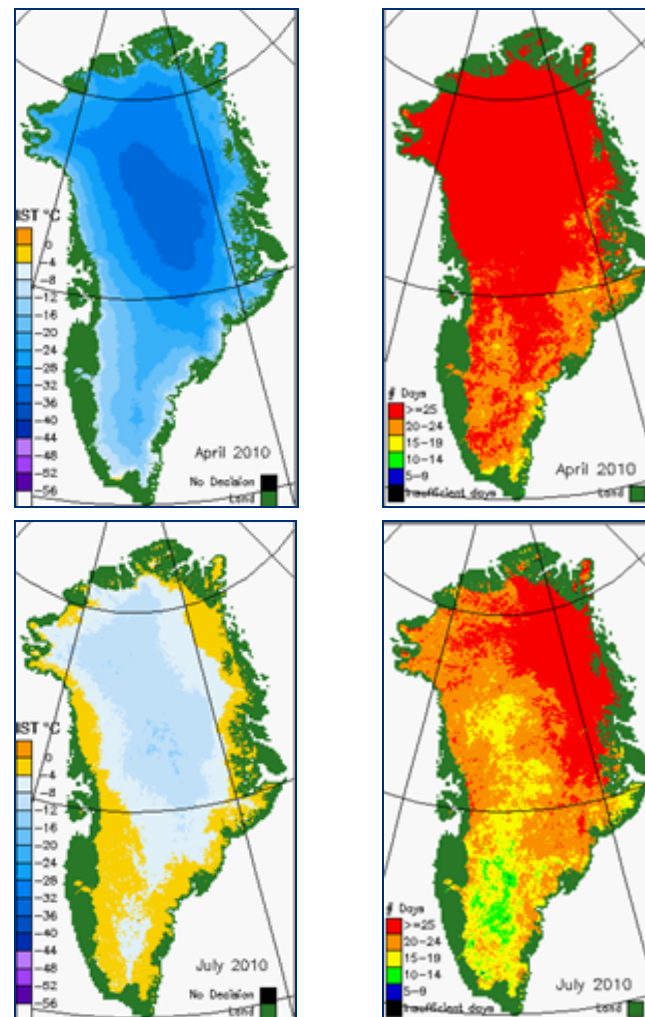


Figure 1: Left column – mean-monthly IST maps for April and July 2010; Right column – number of days available for calculating the mean ISTs shown in the left column.



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Hall, D.K., S.V. Nghiem, C.B. Schaaf, N.E. DiGirolamo and G. Neumann, 2009: Evaluation of surface and near-surface melt characteristics on the Greenland Ice Sheet using MODIS and QuikSCAT data, *JGR - Earth Surface*, 114, F04006.

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Data Sources: Moderate-Resolution Imaging Spectroradiometer (MODIS) data.

Technical Description of Image:

Fig. 1: Left column - Mean-monthly ice-surface temperature (IST) color-coded maps for April and July of 2010 (Hall et al., in preparation).
Right column - Number of days of data available to create the maps for the same months shown in the left column, shown for each grid cell.

AVHRR Polar Pathfinder (APP) data (Fowler, 2002) are currently being reprocessed using an improved cloud masking algorithm. Following reprocessing by the National Snow and Ice Data Center, we will attempt to extend the MODIS IST data record backwards in time to 1981 with the APP data. Following the 2011 launch of VIIRS on NPOESS, we will compare the MODIS IST maps with maps produced using a similar algorithm for VIIRS, thus extending the data record into the future.

Scientific significance: Increased surface temperatures during the melt season cause more-extensive melt and thus more runoff, increasing sea-level rise. To detect trends in IST and melt extent that are statistically significant, we will need a multidecade dataset. The MODIS climate-quality IST dataset is already greater than one decade in duration. It is anticipated that a CDR of >30 years will be created by combining APP, MODIS and VIIRS IST data of the Greenland Ice Sheet. This valuable record will be useful for studying temperature and surface-melt trends and ice sheet mass balance. The MODIS IST data can be compared with data-assimilation output to validate the models, and perhaps could also be also used as model input. A CDR is a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change (NRC, 2004).



High-impact rainfall-triggered landslides in 2010

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A Global Landslide Catalog (GLC) has been developed to record rainfall-triggered landslides. Upon completion of the 2010 catalog, we observed a larger number of reported landslides, fatalities, and fatal landslides across the globe for 2010 compared to previous years (2007-2010).

This research addresses if this active landslide year is associated with anomalous patterns in global or regional rainfall, or if the peak is related to reporting biases in the cataloging process.

To investigate this question, landslides and TRMM 3B42 (TMPA) precipitation data were compared over three test areas with significant landslide activity. Daily rainfall values for 2010 were compared for previous years (1998-2009), considering both monthly totals and daily extreme precipitation values.

Results indicate that 2010 did exhibit anomalously high precipitation totals that occurred in parallel with heightened landslide activity. Increases in monthly rainfall over the sample period was also found to loosely correlate with increases in fatal landslides within these test areas. Findings suggest that global satellite rainfall data could be used to estimate the frequency or extensiveness of landslide triggering to provide more insight into global rainfall-triggered landslide distribution.

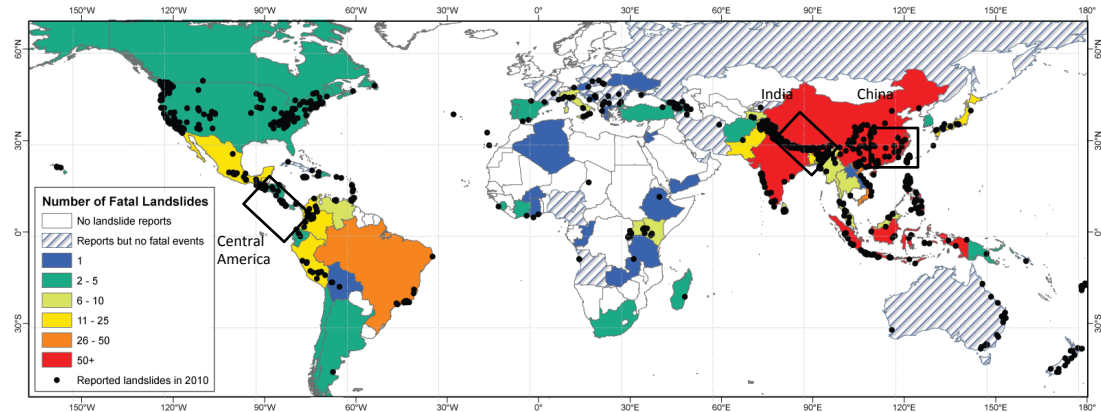


Figure 1: a) Global distribution of fatal landslides for all years of the GLC record (2007 – 2010), the location of 2010 reported events are shown as black dots.

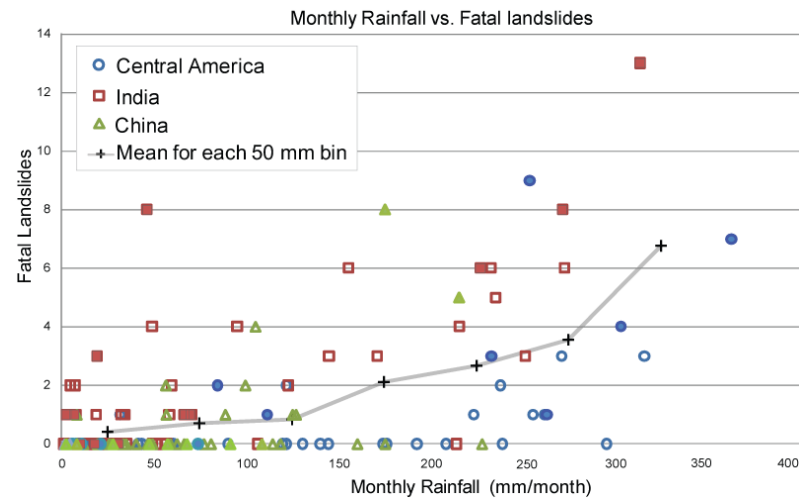


Figure 2: Distribution of monthly rainfall (x-axis) vs. the number of fatal landslides (y-axis) reported for each month from 2007 – 2010 for each of the 3 areas shown in Figure 1. Filled symbols indicate 2010 events. The number of fatal events are averaged for each 50 mm interval and suggest that as the monthly rainfall increases, the number of fatal landslides also generally increases over within the three test areas.



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Data Sources: TRMM Multi-satellite Precipitation Analysis (3B42), Global Landslide Catalog

Technical Description of Images: The Global Landslide Catalog (GLC) includes rainfall-triggered landslides obtained from news reports, disaster databases, personal communication, and scholarly articles. The catalog is compiled on a daily basis and includes information on the date and time of occurrence, geographic location, impacts, and other details. **Fig. 1** maps the global distribution of fatal landslides per country for 2007 – 2010. All reported landslides are shown for 2010 as black dots. During 2010, the GLC recorded a 3-fold increase in the number of reported landslides and a 2-fold increase in the number of fatal events and total fatalities. There are a total of ~2,745 events recorded in the GLC from 2007 – 2010. Work is ongoing to record rainfall-triggered landslide events in 2011. **Fig. 2** illustrates a scatter plots showing the monthly rainfall values for 2007 – 2010 compared with the monthly totals of reported fatal landslides over the same period for each of the test areas. Filled in symbols denote 2010 months. Results indicate that the monthly rainfall in each of these areas tends to scale with fatal landslides, suggesting that as monthly rainfall increases, the GLC records fatal landslides. Findings are generally consistent with reported landslides and daily extreme event statistics.

Scientific Significance: The GLC represents the most comprehensive global catalog of landslide events to date. While it only encompasses 4 contiguous years at present, this study shows how the catalog can be used in concert with global satellite precipitation information to identify relationships between daily and monthly rainfall patterns and landslide activity. Understanding how changes in precipitation intensity and accumulation affects reported landslide activity may shed new light on quantifying or forecasting landslide activity based on rainfall variability at seasonal, annual or decadal scales. These findings will also help to improve the evaluation of a global prototype landslide forecasting framework (Hong et al. 2006, Kirschbaum et al. 2011) to better inform landslide hazard assessment and understand how data and model uncertainty impacts forecast accuracy.

Relevance for future science and relationship to Decadal Survey: New satellite missions such as the Global Precipitation Measurement (GPM) mission (www.gpm.nasa.gov) will help to extend coverage of precipitation and allow for higher spatiotemporal measurement of precipitation for improved characterization of extreme precipitation and potential landslide activity.



Enabling improved soil moisture data assimilation with calibration

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NASA's data assimilation capabilities are the basis for planned Level4 soil moisture products from SMAP, and the typical approach for soil moisture data assimilation involves matching the probability distributions of the remotely sensed soil and modeled soil moistures. In this work, inverse modeling tools developed for the NASA Land Information System are shown to enable model calibration prior to data assimilation.

The results from this synthetic study indicate that a priori land model calibration is an effective strategy for bias mitigation in soil moisture assimilation. The average skill of surface and root zone soil moisture estimates from assimilation with calibration is 0.84 compared to 0.75 when scaling observations to the model's climatology.

The joint use of inverse modeling and data assimilation tools also demonstrates the use of advanced computational tools to enable increased exploitation of observational data for improving land surface hydrological modeling. The results from this study are directly relevant to the effective utilization of observations from the upcoming soil moisture active passive (SMAP) mission.

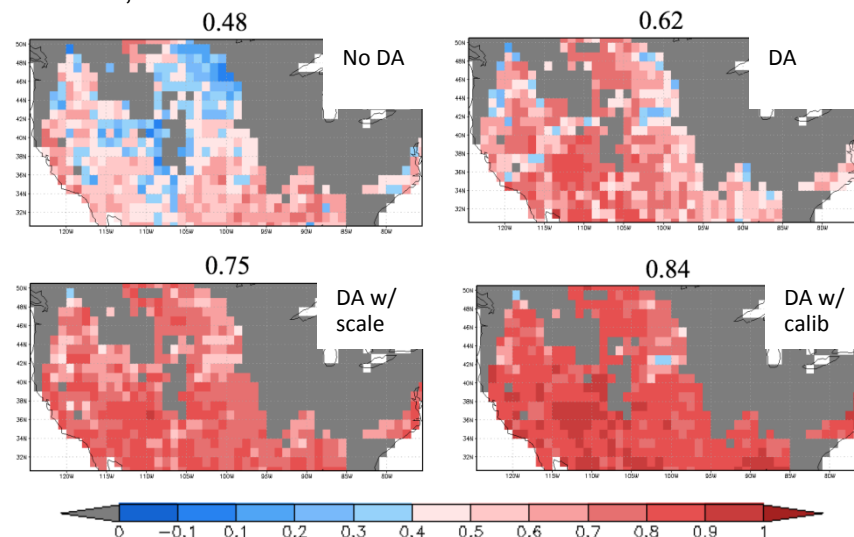


Figure 1: Comparison of surface soil moisture skills from assimilation experiments, where domain average skill is above each plot; No DA-model with no assimilation, DA – assimilation without bias correction, DA w/scale – assimilation with a priori scaling, DA w/calib – assimilation with calibration

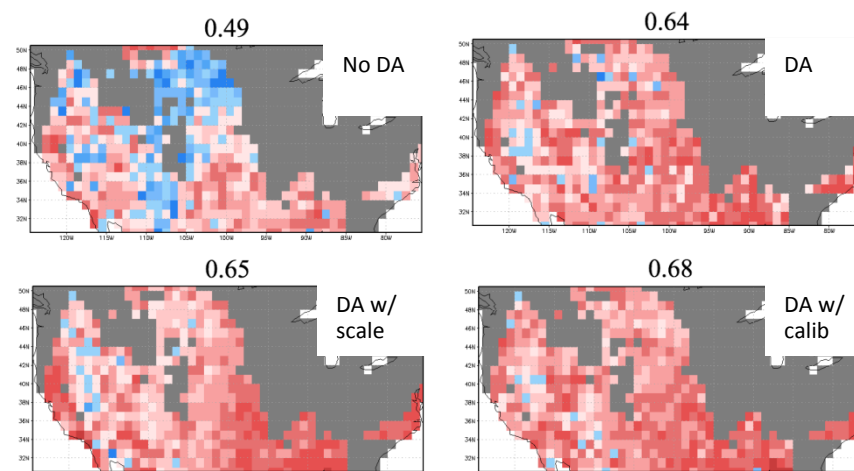


Figure 2: Same as Figure 1, but for root zone soil moisture



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Data Sources: Data used in this study is generated by the Land Information System (<http://lis.gsfc.nasa.gov>) to simulate soil moisture retrievals from the upcoming SMAP mission.

Technical Description of Images: **Figure 1** shows the comparison of surface soil moisture skill in terms of anomaly time series correlation coefficients: (No DA) open loop (model integration with no assimilation), (DA) assimilation without bias correction, (DA w/scaling) assimilation with a priori scaling of observation with CDF-matching, (DA w/calib) assimilation into calibrated model, where parameters are estimated using optimization tools. The grey color represents grid cells excluded from the computations. Titles indicate domain averaged skill values. **Figure 2** is same as Figure1, but shows represents the comparison of root zone skill from different experiments. Overall, the assimilation experiments perform better than the open loop simulation, and the assimilation skill systematically improves. The improvements observed in the root zone estimates are smaller compared to the corresponding improvements in the surface soil moisture skill because only surface soil moisture observations are employed in data assimilation and parameter estimation.

Scientific Significance:

Data assimilation systems require that the errors in the model and the observations are strictly random. As a result, the presence of systematic or bias errors needs to be addressed separately within the data assimilation system. In this study, we evaluate a number of bias mitigation strategies in the context of assimilating surface soil moisture retrievals. Specifically, we examine the use of model parameter estimation as a bias correction strategy prior to data assimilation. This strategy is compared to the typical approach of scaling the assimilated observations to the land model's climatology prior to data assimilation. The results indicate that a priori land model calibration is an effective strategy for bias mitigation in soil moisture data assimilation. Our results also suggest that using model parameter estimation could be a viable strategy especially when dealing with relatively short satellite records, since the a priori scaling approaches such as CDF-matching typically require long records of satellite retrievals to avoid statistical errors associated with limited sample sizes. This result is important for expediting the use of soil moisture retrievals becoming available from new missions such as SMAP. The study is enabled by the advanced capabilities of the NASA Land Information system (LIS) framework, which includes a new subsystem for inverse modeling. This extension encapsulates a range of optimization algorithms suited for both convex and non-convex optimization problems. The joint use of optimization and data assimilation tools presented here demonstrates the use of these computational tools for enabling the increased exploitation of information content from observations to improve hydrological modeling

Relevance for future science and relationship to Decadal Survey: The results from this study are relevant for the upcoming Soil Moisture Active/Passive mission (SMAP). Observations from SMAP will provide the necessary data products to assimilate into land surface models. The study indicates that the use of model parameter estimation may be an effective strategy when SMAP retrievals are used in a data assimilation system. Further, as the a priori scaling approaches to bias correction typically require long records of satellite data, parameter estimation may provide a way to expedite the use of short records of soil moisture from SMAP for land data assimilation.